



# **Applications of High Resolution Airborne Multispectral Imagery**

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# *Airborne Digital Multispectral Imagery*

Fort A.P. Hill, Bowling Green, Virginia



15 October 1999, one-meter spatial resolution



## *Why Airborne?*

# Flexibility & Cost

Spatial:	Lenses and aircraft altitude provide high resolution (i.e., small pixels)
Spectral:	Interchangeable filters provide unique band combinations
Radiometric:	Operator control over integration time (shutter speed) and apertures (f-stop) to ensure optimal image contrast
Temporal:	Acquire imagery when you want
Media:	Digital

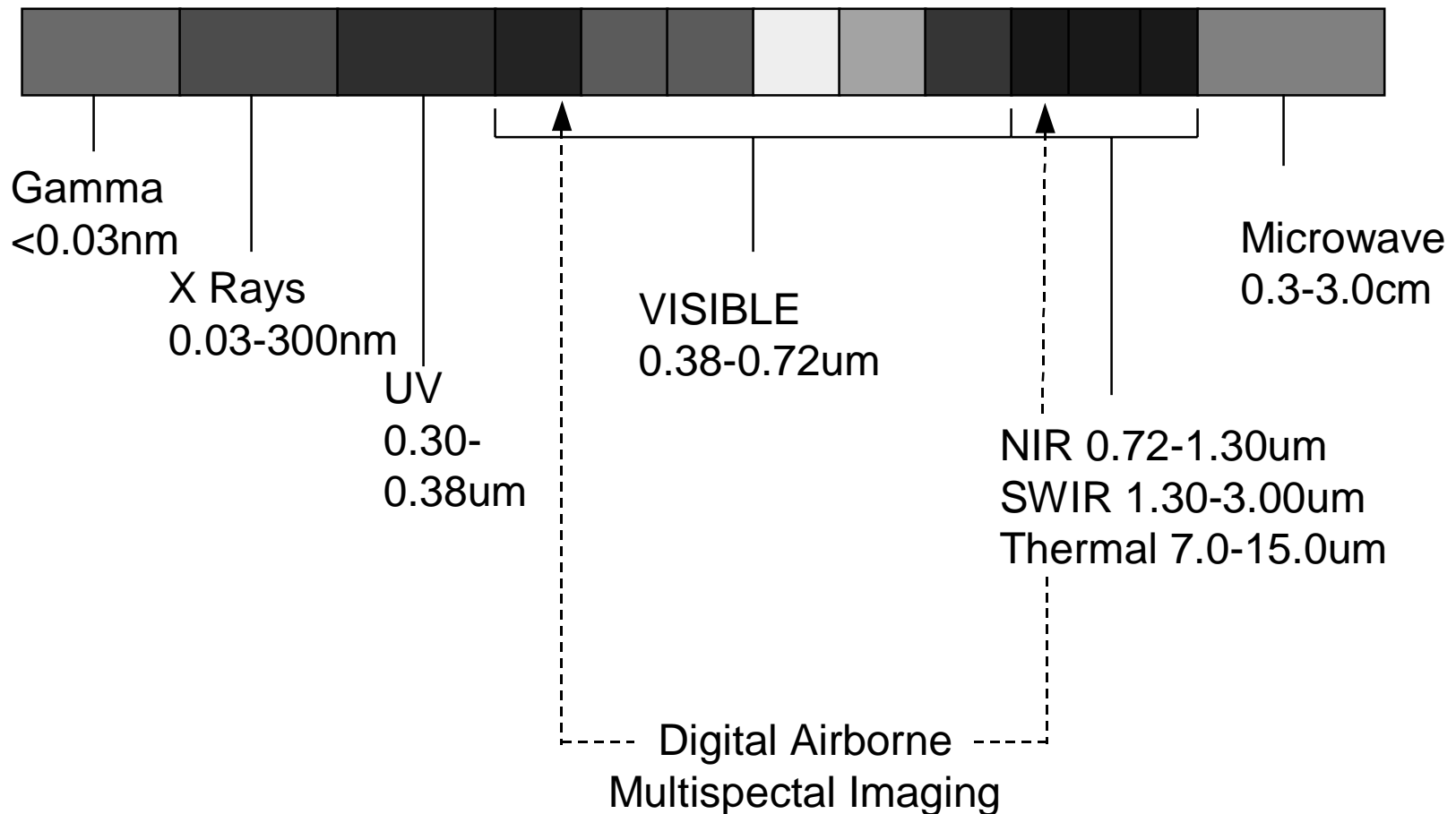
Compare airborne digital multispectral sensor characteristics with:

- aerial photography - analogue, limited spectral resolution
- satellite imagery - limited spatial resolution, fixed temporal resolution



## *Wavelengths*

### MAJOR DIVISIONS of the ELECTROMAGNETIC SPECTRUM





## **Computerized Airborne Multi-camera Imaging System (CAMIS)**

- Four cameras (camera spectral range: 350 - 900 nm)
- 768 x 576 pixel array
- 16 mm focal length lenses
- Imagery collected @ 6100 ft agl provides ~ 1 m<sup>2</sup>/pixel
- 25 nm bandpass filters

Band 1: 450 nm (blue)

Band 3: 650 nm (red)

Band 2: 550 nm (green)

Band 4: 800 nm (near infrared)



# CAMIS



## Onboard Configuration:

- Cameras
- Pentium II PC with vendor software
- Flatscreen monitor for real-time image display
- Code phase GPS antenna to record nominal coordinate for each frame center
- DC to AC power inverter



## Typical Aircraft:

- Cessna 172 Skyhawk
- Navigation using code phase GPS with moving map
- Static camera mount

(Photo displays CAMIS mounted in a Cessna 208 using standard large format aerial camera port.)



# *Lake Okeechobee, Monkey Box*

**False-Color Composite = CAMIS bands 4, 3, & 2**  
**Acquired 10 December 2001**



Image depicting distribution of water hyacinth (*Eichhornia crassipes*)



# *Lake Okeechobee, Monkey Box*

**True-Color Composite = CAMIS bands 3, 2, & 1**  
**Acquired 10 December 2001**

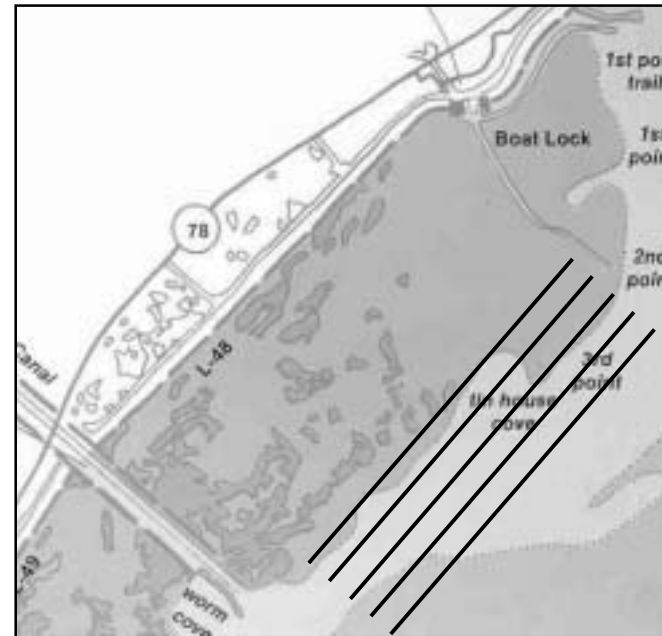


Objective: Develop a cost effective methods for periodic image acquisition and processing to delineate invasive aquatic species (e.g., water hyacinth [*Eichhornia crassipes*], water lettuce [*Pistia stratiotes*])





## *Invasive Aquatic Plant Mapping, COE Jacksonville District*

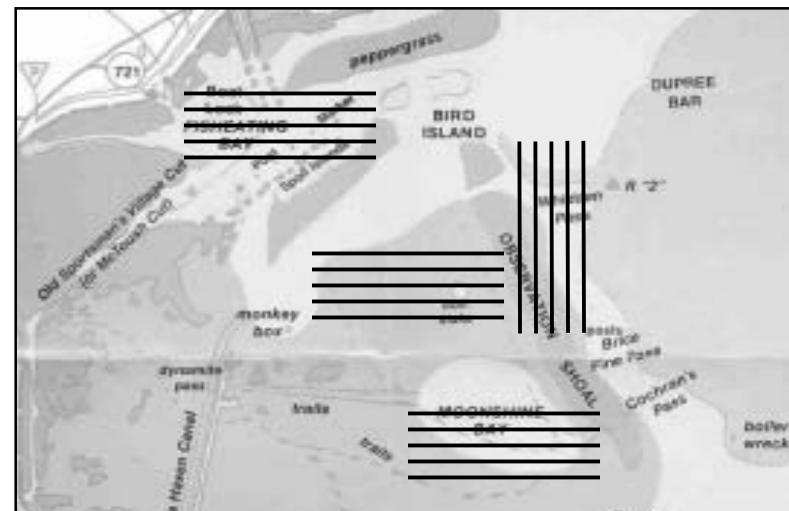


Imagery acquired:  
31 January 2001  
10 December 2001

Spatial Resolution:  
one meter

Five study areas

Species of Concern:  
- water hyacinth,  
- water lettuce,  
- hydrilla, and  
- others



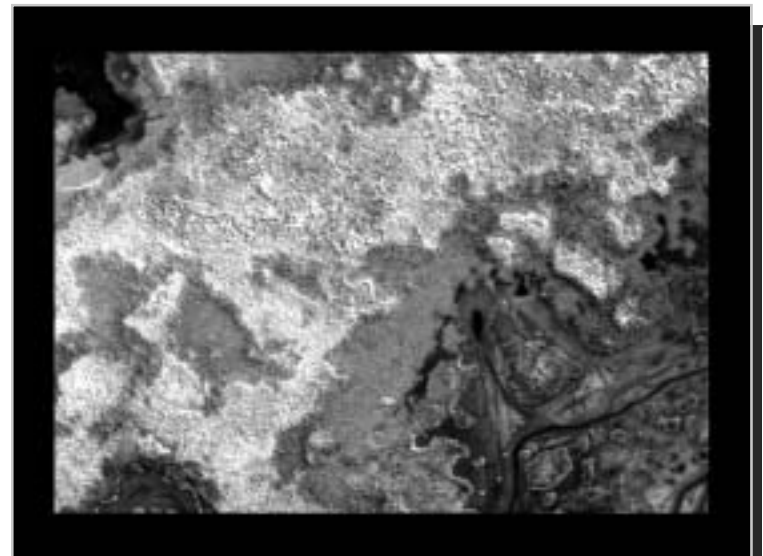
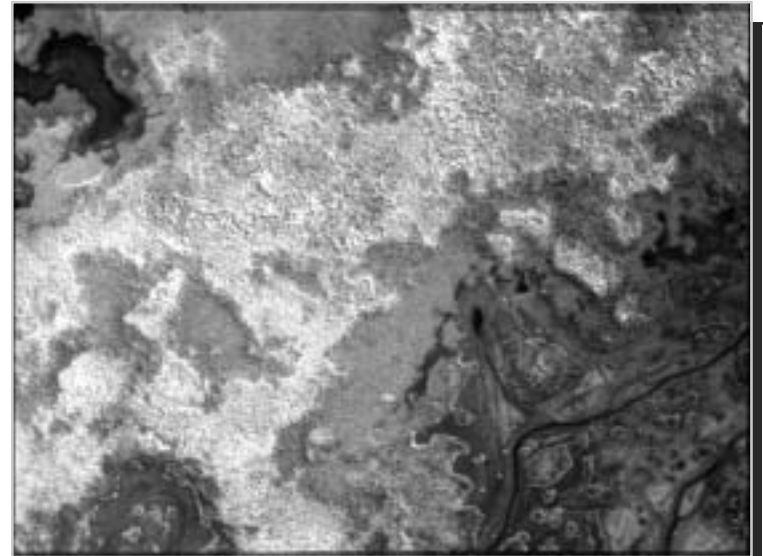


# *Image Post-Processing*

- Band-to-Band Registration
- Within Frame Radiometric Effects
  - $\cos^{-4}$
  - vignetting
  - BRDF
- Flightline-to-Flightline Radiometric Normalization

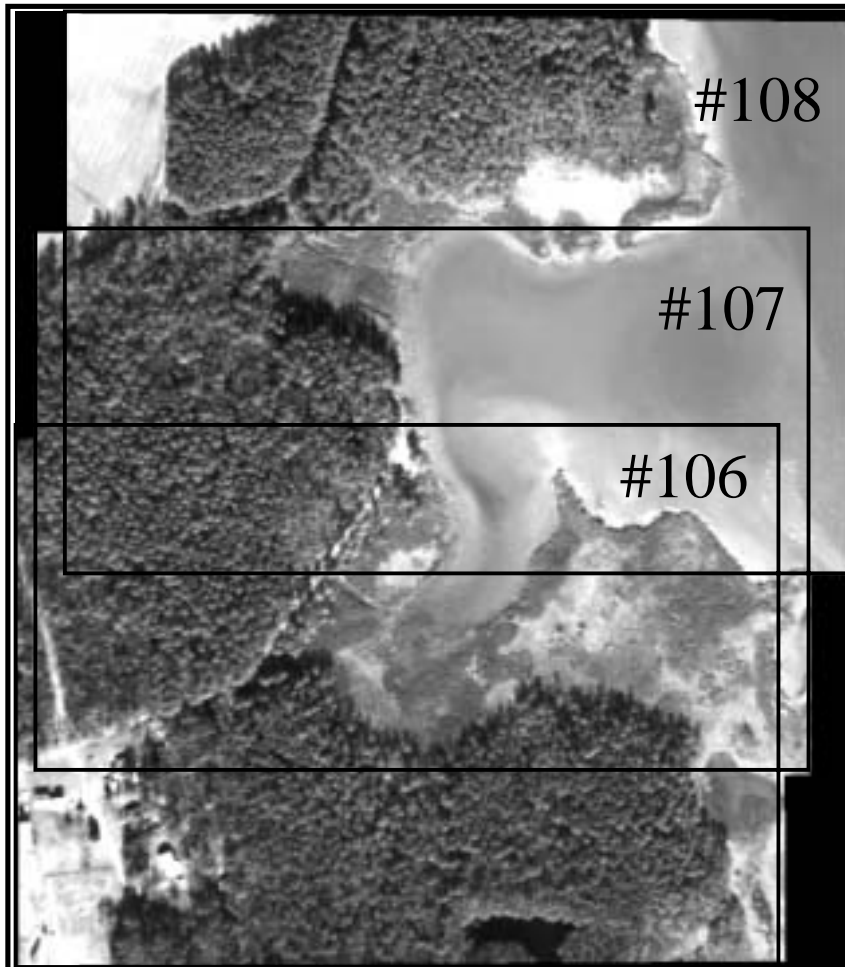
Commercial image processing software typically performs the following geometric corrections:

- Pixel-to-Pixel Registration
- Geometric Rectification





## *Image Post-Processing (con't)*



Frame-to-Frame  
Registration and  
Mosaicking



# *Florida Field Data Collection*





# *Cooperation*

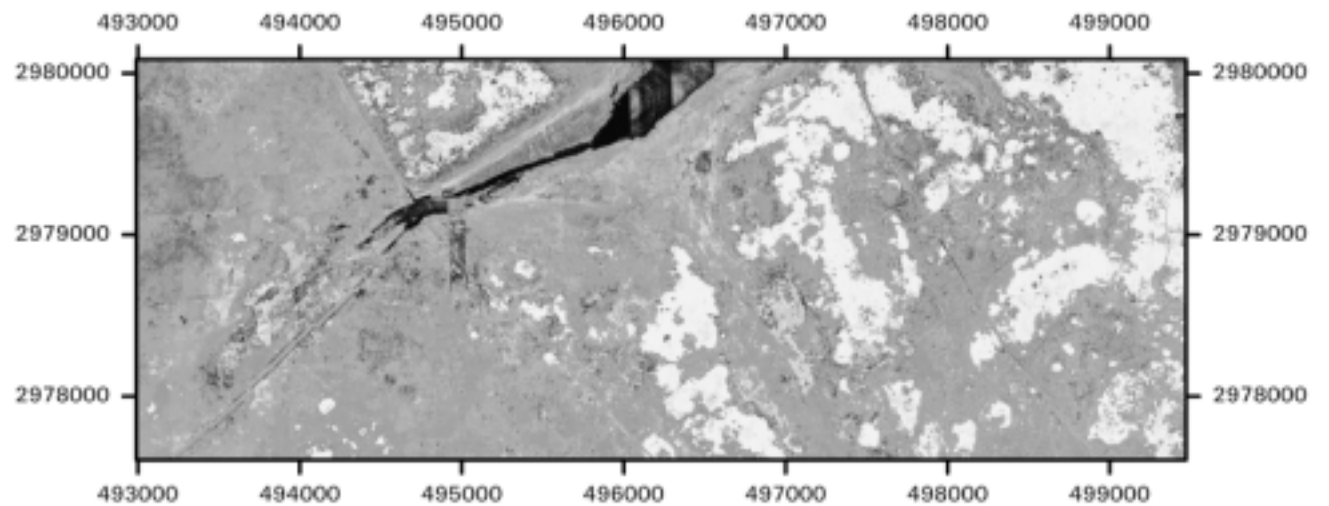




# *Lake Okeechobee, Monkey Box*

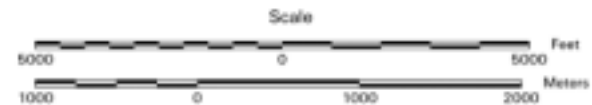
## Vegetation Classification of Monkey Box Site, Lake Okeechobee, Florida

Full Resolution



### Vegetation Classes

water	dead eleocharis
water/veg mix	dead typha
panicum	lettuce
torpedo grass	hyacinth
torpedo grass - young	hyacinth/grass
smartweed	duckweed
smartweed/panicum	lily
mixed veg	phragmites

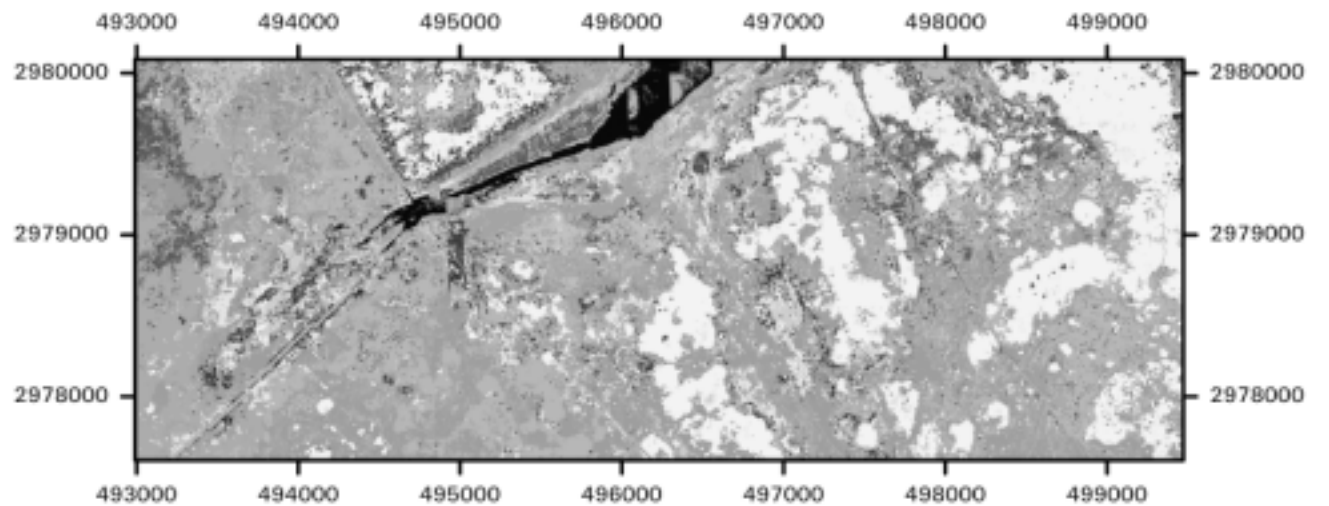




# *Lake Okeechobee, Monkey Box*

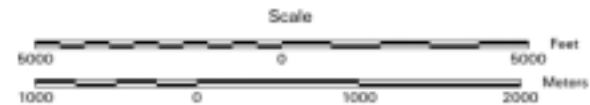
## Vegetation Classification of Monkey Box Site, Lake Okeechobee, Florida

Minimum Mapping Unit = 25 sq.m.



### Vegetation Classes

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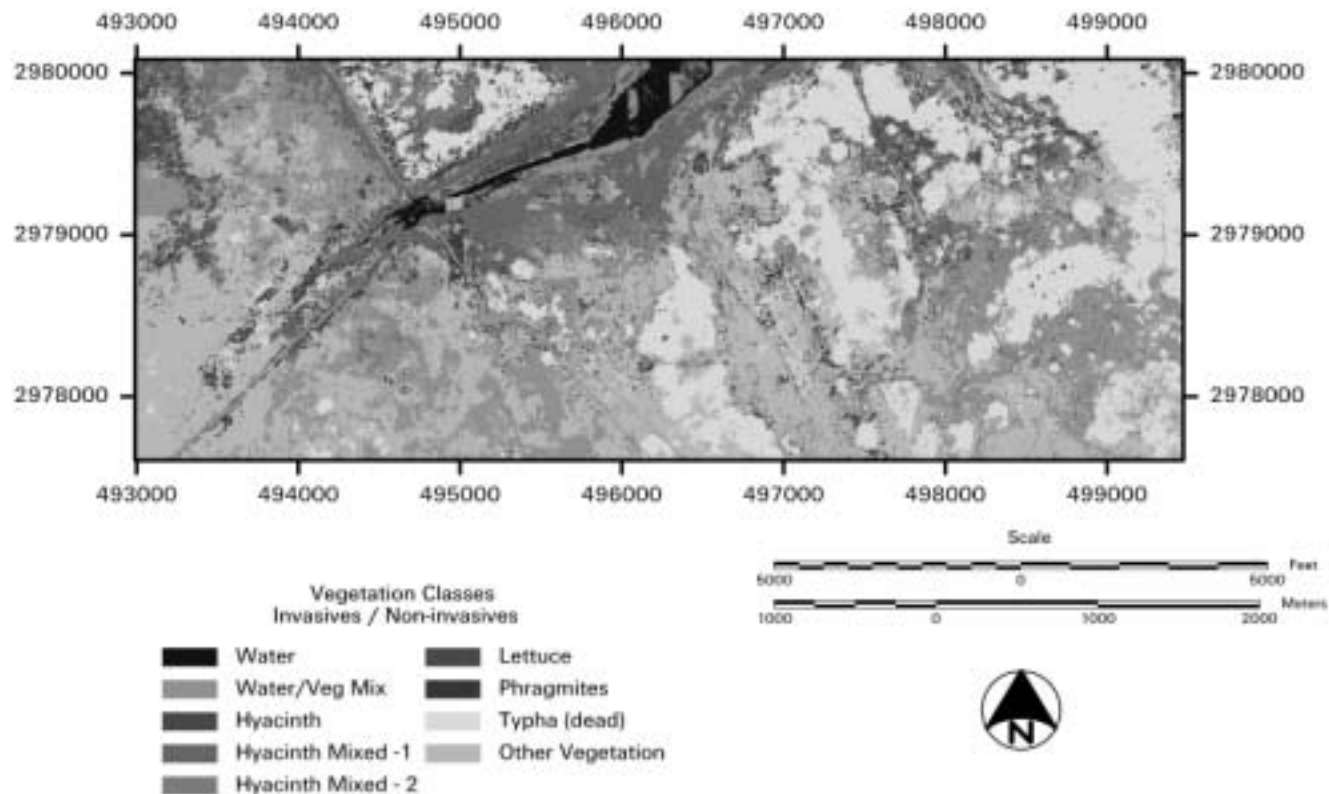




# *Lake Okeechobee, Monkey Box*

## **Vegetation Classification of Monkey Box Site, Lake Okeechobee, Florida**

**Minimum Mapping Unit = 25 sq.m. & Recoded**

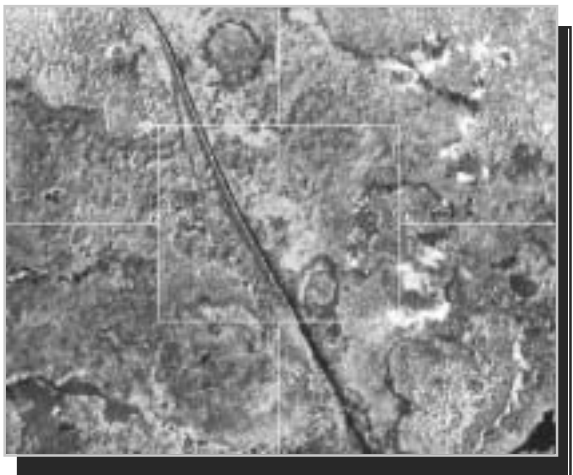




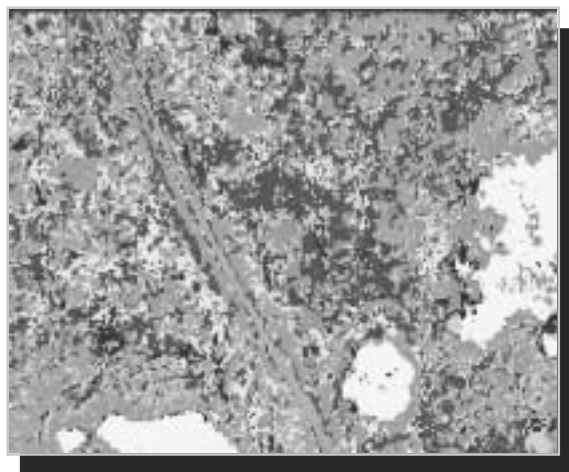
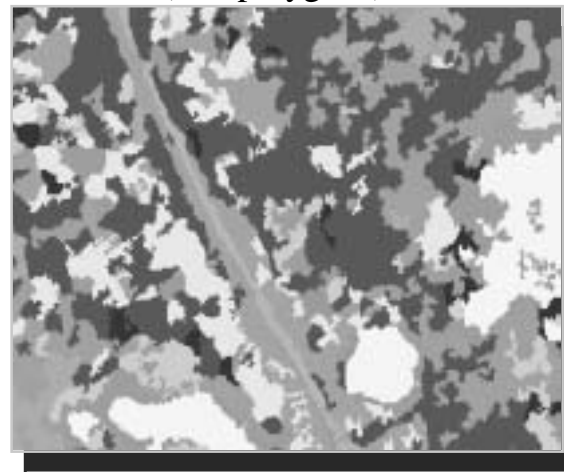


# *Lake Okeechobee, Monkey Box*

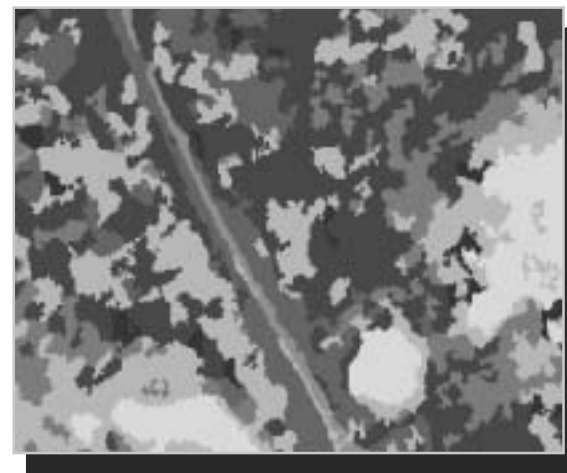
Multispectral Mosaic



Thematic Map – MMU  
(264 polygons)



Thematic Map – Full Resolution  
(9,975 polygons)



Thematic Map – MMU & Recoded  
(198 polygons)



# *Lake Okeechobee, Satellite Imagery*

Acquired 24 May 2002



An example of QuickBird 2 multispectral imagery. The commercial satellite is owned and operated by Digital Globe (Longmont, CO).

## Specifications:

Launched on 18 October 2001  
Sun-synchronous orbit at 450 km

## Spectral Resolution:

Four-band multispectral –  
blue, green, red, NIR

Panchromatic

## Radiometric Resolution:

11-bit

## Spatial Resolution:

2.8 m for multispectral

0.7 m for panchromatic

## Temporal Resolution:

1 to 3.5 days revisit period



# *Lake Okeechobee, Cost Estimates*

## **Airborne Imagery**

Total Cost for Five Study Sites  
(~ 70 km<sup>2</sup>)

Image Acquisition = \$10,000 – 15,000

Post-Processing = \$10,000 – 15,000

Image Classification:

Field Data = \$3,000 – 5,000

Image Processing = \$3,000 – 5,000

Total = \$26,000 – 40,000

\$ 370 – 570 per km<sup>2</sup>

\$ 3.70 – 5.70 per hectare

\$ 1.50 – 2.25 per acre

Entire Area ~ 1,000 km<sup>2</sup>

Total Cost ~ \$370,000 – 570,000

## **Satellite Imagery**

Total Cost for Complete Coverage  
of Western Lake Okeechobee  
(1,000 km<sup>2</sup>)

Image Acquisition = \$20,000 – 35,000

Image Classification:

Field Data = \$5,000 – 8,000

Image Processing = \$3,000 – 5,000

Total = \$28,000 – 48,000

\$ 28 – 48 per km<sup>2</sup>

\$ 0.28 – 0.48 per hectare

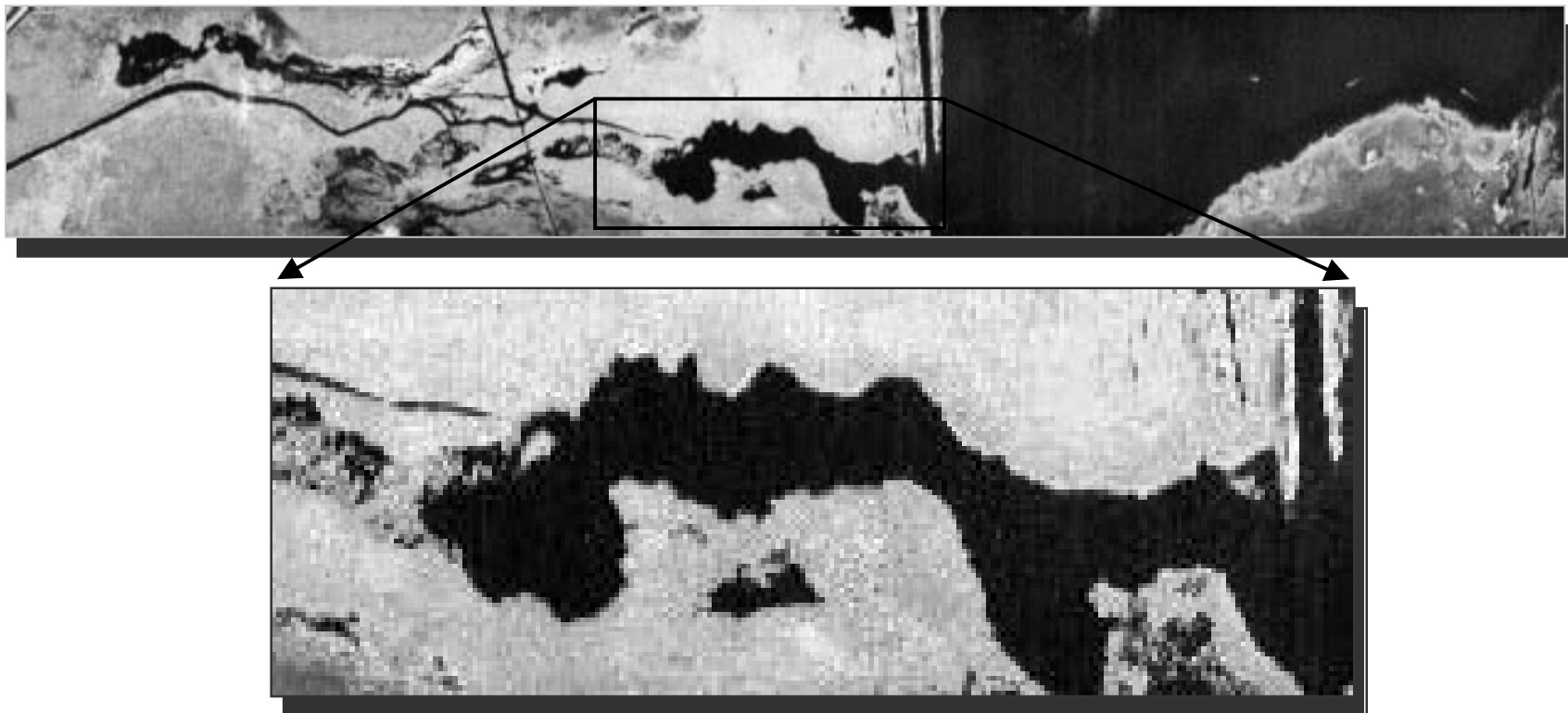
\$ 0.11 – 0.18 per acre

Temporal Problem: When will satellite  
data be acquired and delivered?



# *Lake Okeechobee, Fisheating Bay*

**Hyperspectral imagery acquired using AVSIS**  
(Airborne VNIR and SWIR Imaging Spectrometer)

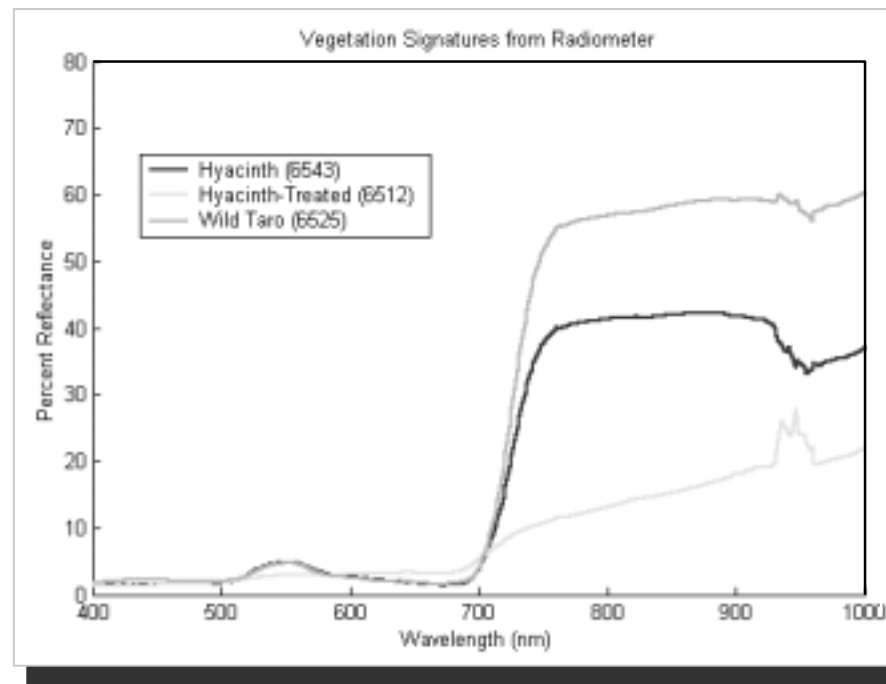
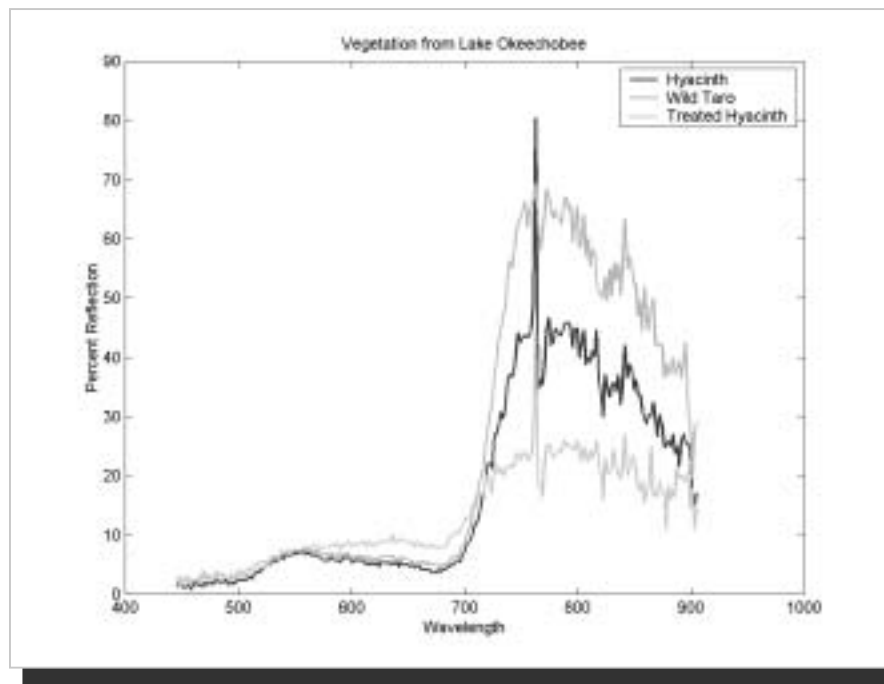


- Pushbroom scanning system
- Prism-Grating-Prism (PGP) dispersing component
- 400 – 1100 nm spectral range (5 nm band width)
- 240 spectral bands
- 12-bit radiometric resolution
- 320 pixel swath width
- ~ 2-meter spatial resolution
- Acquired 10 Dec 2001



# Lake Okeechobee, Fisheating Bay

## Spectral Properties of Airborne Hyperspectral Imagery



**Water Hyacinth - untreated**



**Water Hyacinth - treated**



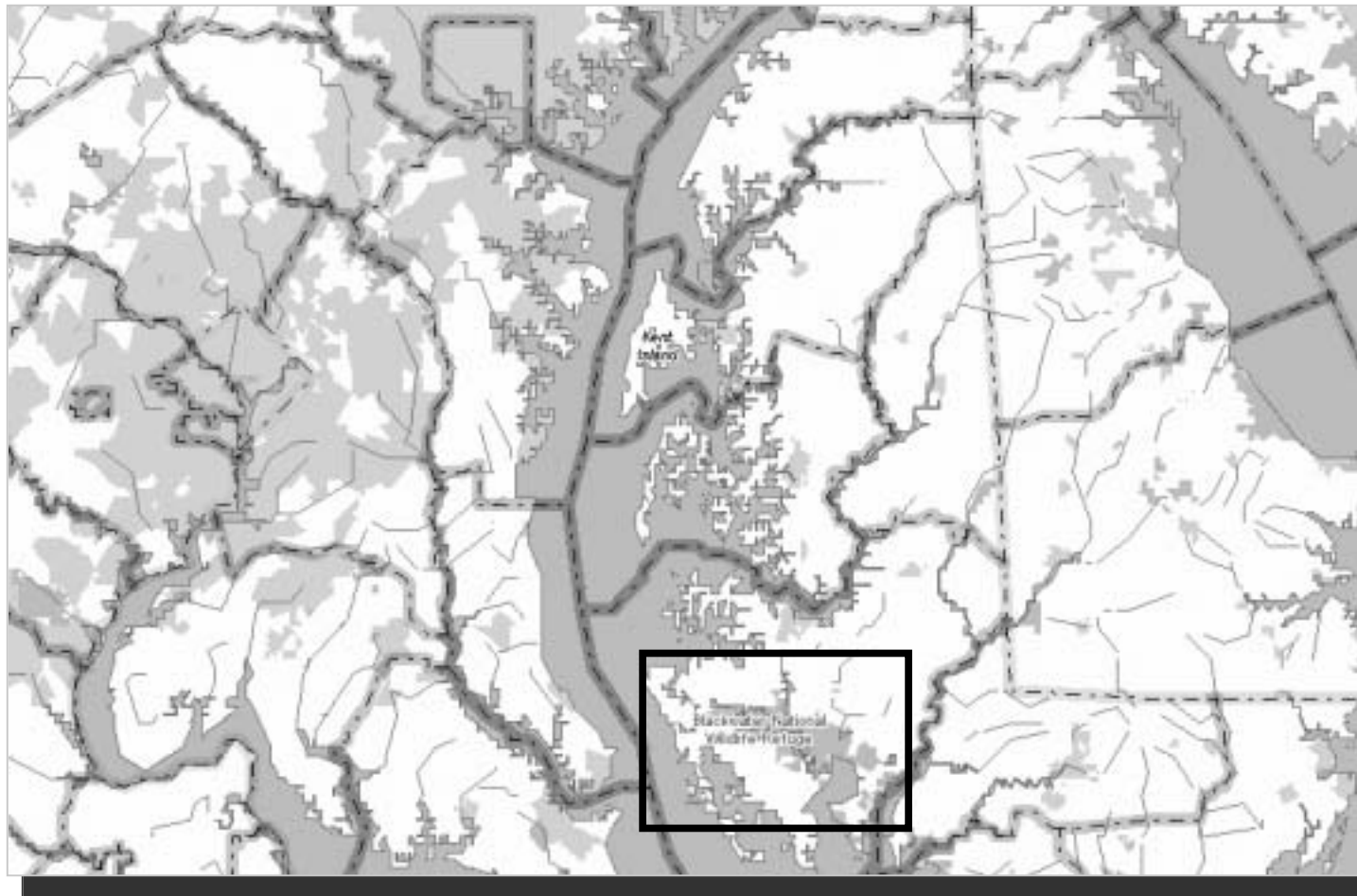
**Wild Taro (*Colocasia esculenta*)**





# *Wetland Vegetation Mapping, Baltimore*

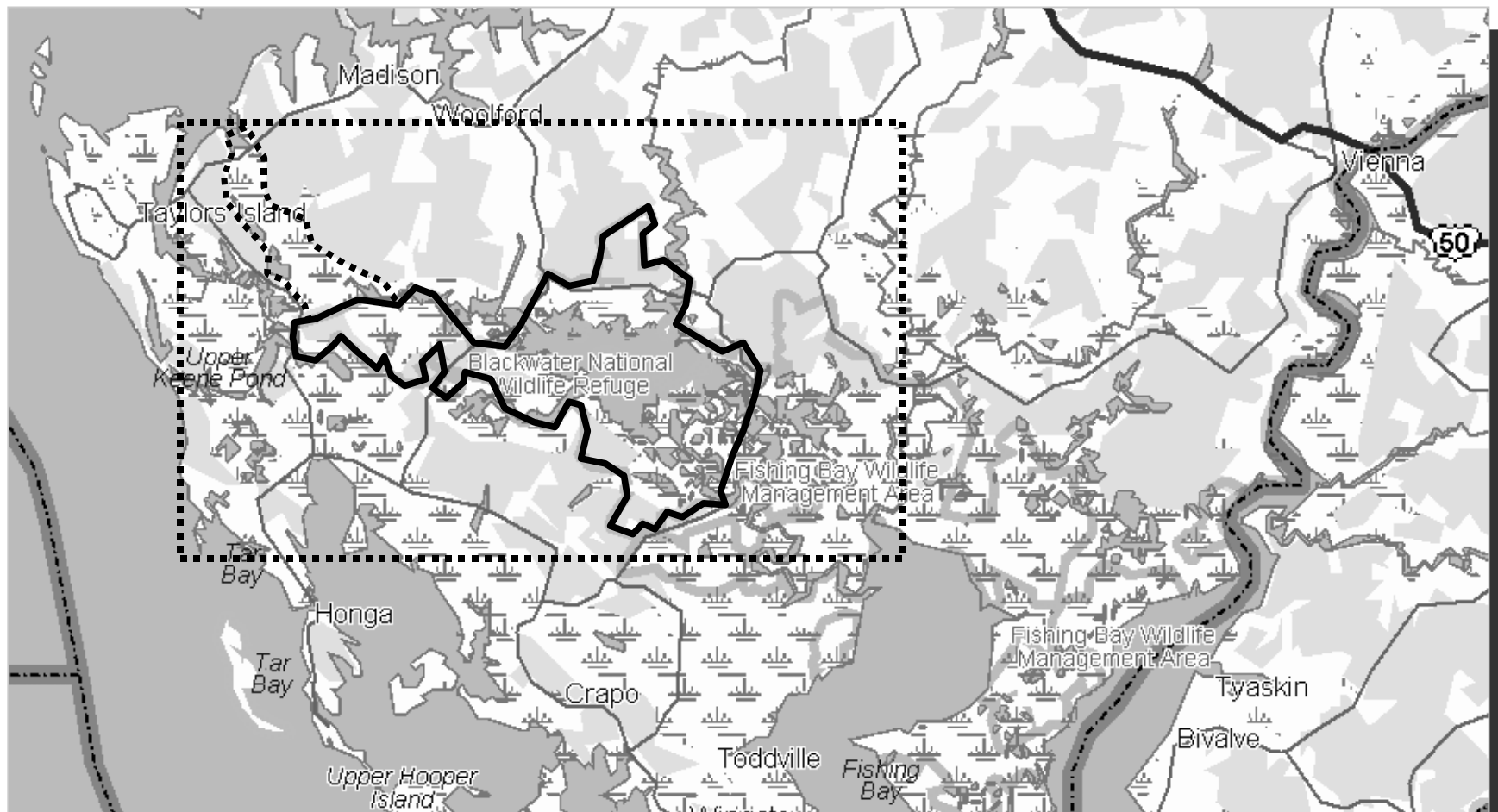
## **Location of Blackwater Wildlife Refuge**





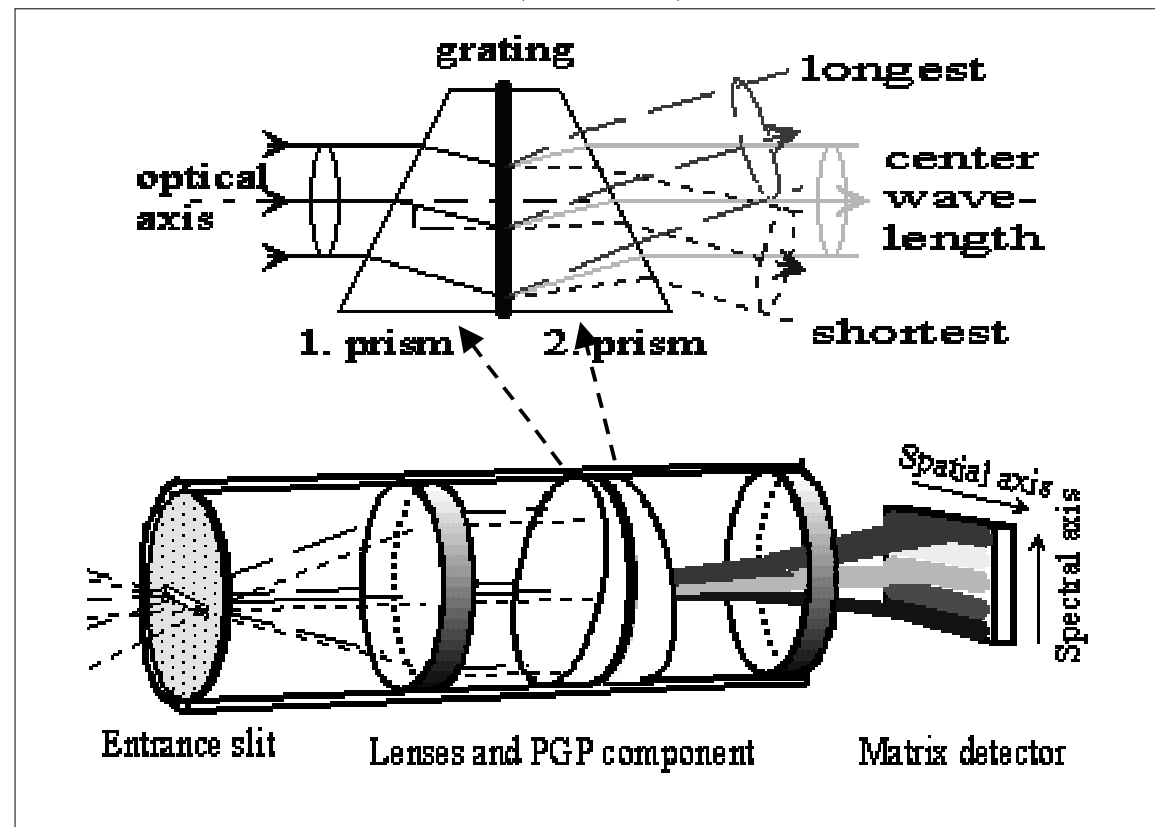
# *Wetland Vegetation Mapping, Baltimore*

**Extent of Blackwater Wildlife Refuge and  
area covered by hyperspectral imagery**





## Airborne Imaging Spectrometer for Applications (AISA)

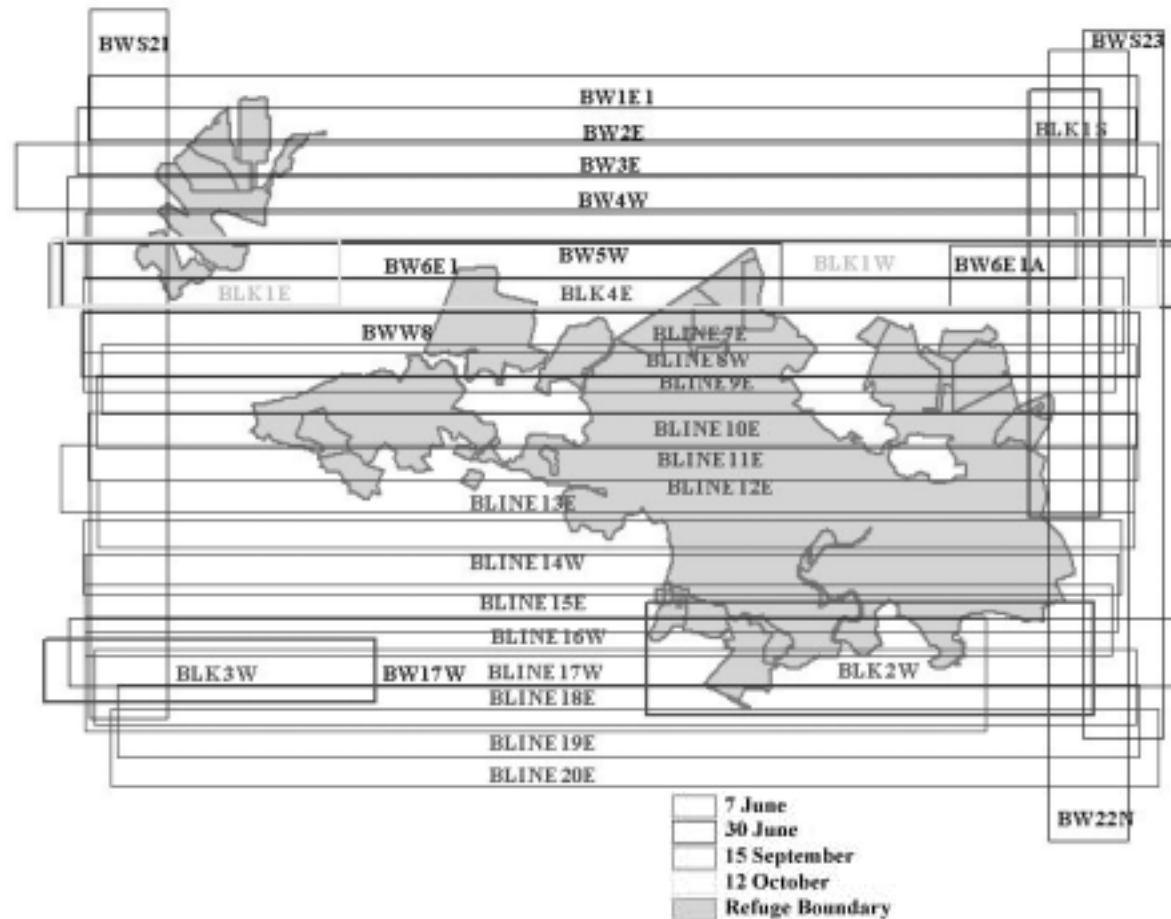


Manufactured by Specim (Finland). Operated by 3Di LLC (Easton, Maryland).





# Flight Plan



Orientation and dates of acquisition for AISA flightlines.



# *Pushbroom Scanner Data*

## **BLINE7E**



Flightline: BLINE7E  
Date: 7 June 2000  
Size: 614 rows x 8344 columns  
(5,123,216 pixels)  
Number of Background Pixels: 2,360,266

## **BLINE8W**

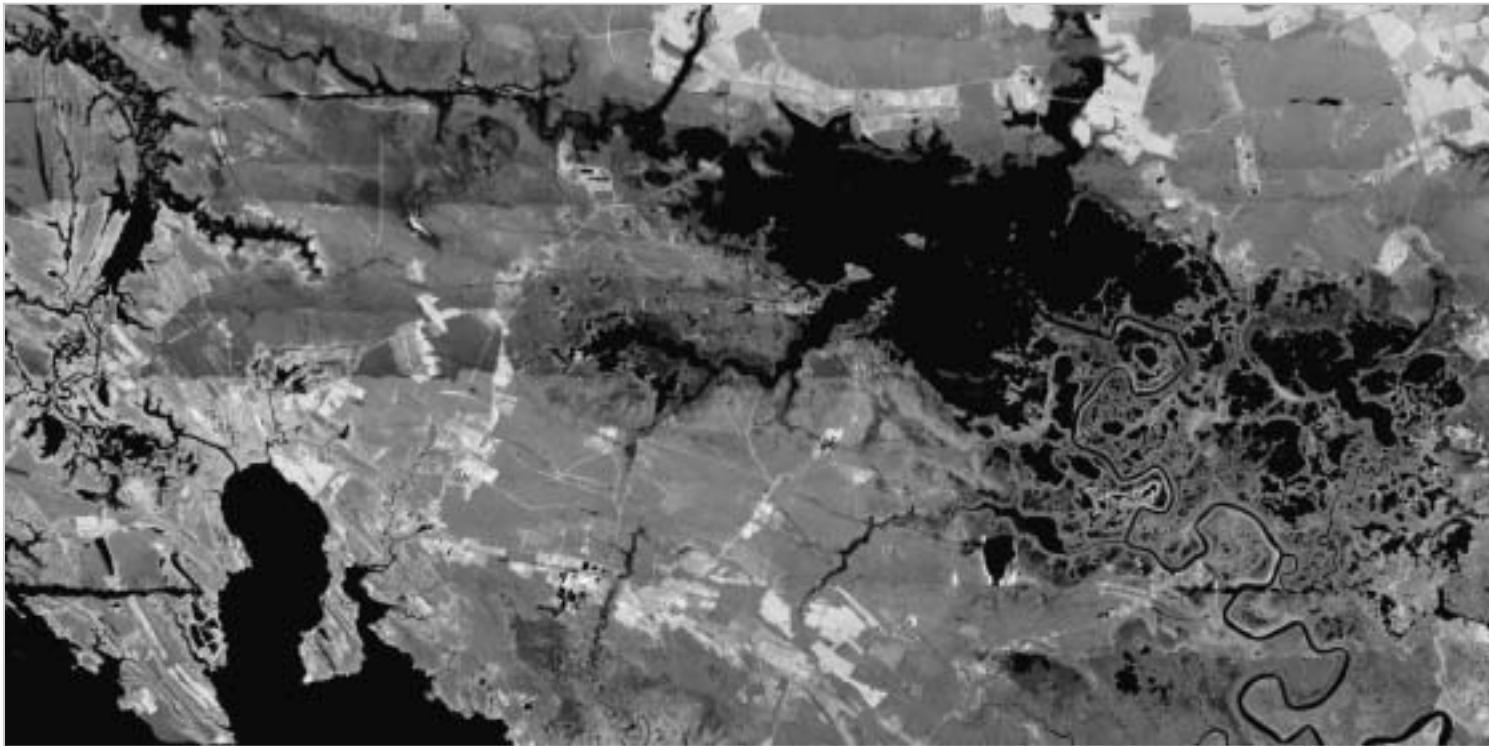


Flightline: BLINE8W  
Date: 7 June 2000  
Size: 657 rows x 8269 columns  
(5,432,733 pixels)  
Number of Background Pixels: 2,701,404



# *Wetland Vegetation Mapping, Baltimore*

**False-Color Composite = AISA bands 32, 22, & 12**

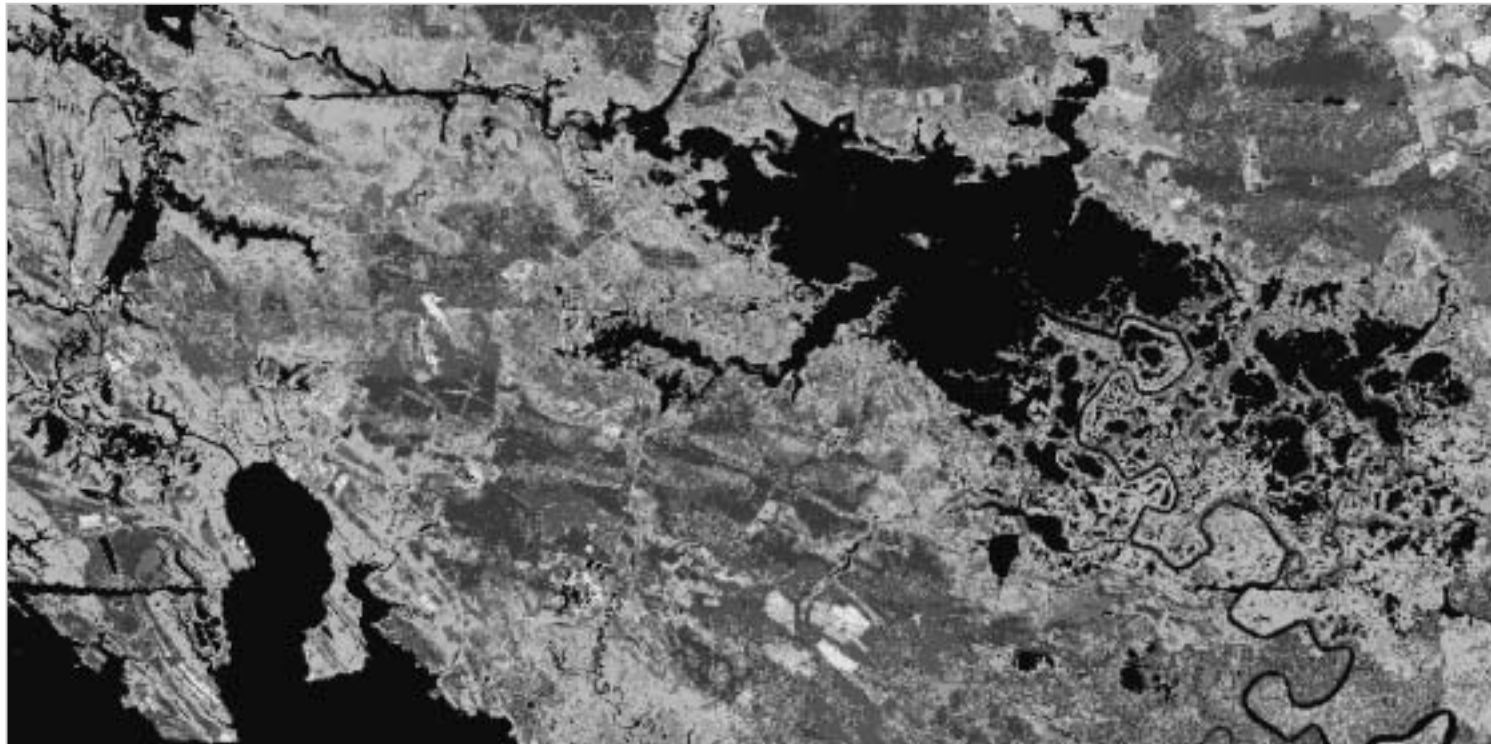












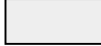





High resolution airborne hyperspectral imagery covering over 100,000 acres of the Blackwater Wildlife Refuge (Cambridge, MD): 4-meter spatial resolution, 38 bands with 3-5nm spectral resolution, 12-bit radiometric resolution, 20 overlapping flightlines.



# *Wetland Vegetation Mapping, Baltimore*

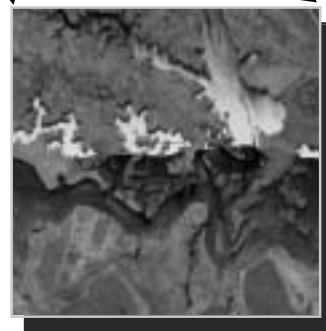
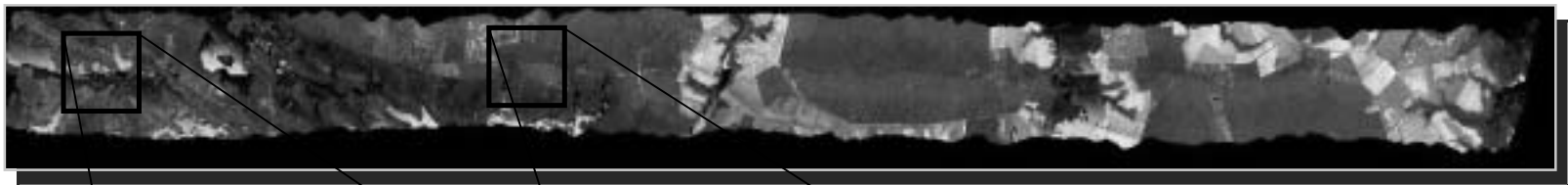
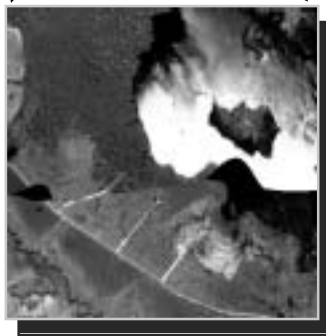
## Preliminary Vegetation Classification



 Pine	 Hardwood-high	 Pine Mix	 Juncus spp.
 Pine-Oak	 Cut Forest	 Shrub	 Three-Square
 Pine-Hardwood	 Transition Forest	 Agriculture	 S. alterniflora
 Hardwood-low	 Low Forest/Shrub	 Dead Forest	 S. patens



# *Radiometric Distortions*





# ***Blackwater Refuge, Cost Estimates***

## **Airborne Hyperspectral Imagery**

Total Cost for Wildlife Refuge  
(~ 400 km<sup>2</sup>)

Image Acquisition = \$20,000

Post-Processing = \$75,000

Image Classification:

Field Data = \$3,000 – 5,000

Image Processing = \$25,000

Total = \$125,000

\$ 312 per km<sup>2</sup>

\$ 3.12 per hectare

\$ 1.22 per acre

## **Airborne Multispectral Imagery**

\$ 370 – 570 per km<sup>2</sup>

\$ 3.70 – 5.70 per hectare

\$ 1.50 – 2.25 per acre

Total = \$148,000 – 228,000

## **Satellite Multispectral Imagery**

\$ 28 – 48 per km<sup>2</sup>

\$ 0.28 – 0.48 per hectare

\$ 0.11 – 0.18 per acre

Total = \$11,200 – 19,200